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BIOREMEDIATION METHOD WHICH IS USED TO CONCENTRATE AND ELIMINATE RADIONUCLIDES IN RADIOACTIVE WATER

TECHNICAL ASPECTS

Nuclear Industry, Managing Radioactive Waste, Treating Contaminated Waters.

PRIOR STATE OF THE ART

During the past few years, bioremediation procedures have been developed that consistently use microorganisms to recover contaminated environments. These efforts have been made mainly for land contaminated by chemical, toxic, or dangerous products using microorganisms. In this way, the bioremediation concept has begun to be implemented. However, the use of microorganisms to recover the environment has been known for more than seventy years in purifying wastewaters. Bioremediation procedures have also been applied to manage radioactive waste in repositories, but never in the containment area of a nuclear power plant, which is the object of the present patent.

The objective of the pools used to store the spent nuclear fuel is to cool down the spent fuel coming from the reactor that still contains high levels of radioactivity and generates a high quantity of heat. Despite the fact that the water in the nuclear pools acts as an efficient shield against radiation, the levels, which the employees working in the surrounding area are exposed to, are considerable. The purpose of the procedure which will be described is to lower the levels of radioactive contamination in the nuclear pools and, as a result, reduce the level of radiation surrounding them as well as the rate of exposure.

Currently, the radioactive water of the nuclear pools is treated with a system of demineralising filters made from ion-exchange resins whose goal is to retain the dissolved substances and those in suspension that can be found in the water, such fission and corrosion products, etc. so that the water is much clearer and the radioactivity in the area

surrounding the pools is significantly lower. As time passes, the life expectancy of the resins is lowered and it is necessary to store them in drums and to treat them as radioactive waste. The following bioremediation procedure, however, retains the nucleotides found in the radioactive water before they reach the resin of the demineralising filters, and as a result, increase their life expectancy, thus reducing the volume of radioactive material to be managed. The material used for the procedure that is being patented, unlike the resins, can be decontaminated and managed as non-radioactive material.

DESCRIPTION OF THIS INVENTION

As previously mentioned, to concentrate and eliminate radionuclides from the radioactive water of nuclear pools, a completely innovative bioremediation procedure has been invented that is applied during the treatment of the water in the pools, before it is re-emptied into them.

In this procedure, the radioactive water from the nuclear pools under treatment, goes through a bioreactor that contains a metallic material, such as titanium or stainless steel, wound into a ball, or any other material that is non-corrosive or non-degradable in this environment and can be colonised by the microorganisms that exist in this type of water. As it goes through the bioreactor, the radioactive water to be treated comes into contact with the material of the ball placed inside, thus forming a biofilm that retains the radionuclides. The microorganisms are capable of retaining the radioisotopes present in the water of the pools by one or more of the following mechanisms: bioadsorption, bioabsorption, bioaccumulation, biosolubility, bioprecipitation.

The water then goes out from the opposite end of the continuous-flow entrance and, before going back into the pool, it goes through a system of demineralising filters.

Finally, the material of the bioreactor is replaced by fresh material. The biofilm that colonises the material and retains the radionuclides is economically eliminated by any

conventional radiochemical decontamination procedure and the radionuclides can be concentrated in a small volume of eluent to be recuperated, completely disposed of, or contained. At this point, the material from the bioreactor can then be managed like non-radioactive material. Both processes, the concentration of radionuclides in a reduced volume and the management of the used materials as non-radioactive, contribute to the cost-effectiveness of the procedure.

The type and size of the bioreactor, the flow of the circulating radioactive water to be treated, and the periodicity of the elimination of the biofilm are conditioned depending on the specifications of each of the water-treatment plants found in the hot area of the different nuclear power plants.

The first objective of this procedure consists in taking advantage of the capacity that some microorganisms in the radioactive waters of the pools have in order to colonise the material placed inside the bioreactor. These microorganisms that cannot be cultivated or manipulated in a laboratory are known in the technical bibliography as VBNC (viable but not cultivable.

In order to accelerate the concentration of radionuclides, the other objective of this procedure consists in previously cultivating the ball, or a similar device, in the presence of a microorganism or a mixture of these. The microorganisms would have to have been previously isolated from the radioactive water to be treated.

DETAILS OF THE EMBODIMENT

The first part of the procedure consists in preparing the material that will be placed inside the bioreactor. This material can be made, for example, from braided stainless steel wool and shaped into a 20-gram ball with a surface area of 0.01 $m^2.g^{-1}$. It is then degreased using acetone in an ultrasound bath and sterilised in an autoclave at 121 °C for 15 minutes. In aseptic conditions, the balls are then placed inside a stainless-steel cylindrical bioreactor that is 250-mm high and 90-mm in diameter. An entrance is placed at the bottom so that the

water can enter, and an exit is placed at the top where the water can escape. The next step in this procedure consists in pumping an average of 3-cubic meters of radioactive water from a spent nuclear fuel pool per hour. The qualitative isotopic composition of the said water is usually ^{60}Co, ^{137}Cs, ^{134}Cs, ^{65}Zn, and ^{54}Mn. As of this moment, the material inside the bioreactor begins to be colonised by the microorganisms present in the radioactive water and the radionuclides are retained. With this procedure, which is applied to a BWR (boiling-water reactor) type nuclear power plant as the one where the experimental prototype was carried out, it is possible first to concentrate and then to eliminate the ^{60}Co radionuclide.